G. Höpner Petersen (Zoologisches Museum, Kopenhagen), Gastdozent am Institut für Polarökologie der Universität Kiel

A comparison between arctic and antarctic ecosystems

My first encounter with the antarctic fauna was a shock to me, so this paper will be presented in a rather personal form. The shock arose from confrontation with a reality which constrasted sharply with what I had previously gathered from literature, talks and own experience from arctic regions. Thus I had adopted the well known theory, that the development of the Antarctic Circumpolar Current started c. 20 M.Y. ago, following the opening of Drakes Passage and causing the glaciation on the Antarctic continent, which was pressed down by the weight of the ice. So the shelf became much deeper than usual. Hence I had expected to find traces of a benthos fauna developed from a shallow shelf fauna. This expectation was based on a knowledge of the North Atlantic fauna from the Baltic, North Sea, Faroes and Greenland. I had compared these faunas with those in the Mediterranean, the Caspian and Red Sea, and in the Andaman, Canadian and Alaskan Seas and also with some fossils. The conditions in the North Atlantic were physically rather similar to the South Atlantic, with ice cover during six months. I had expected to find the South Atlantic fauna more similar to the North Atlantic than to the faunas from the other seas, and I was greatly surprised to find that this was not the case.

The cruise "Polarstern" Ant V-1 in May and June 1986, where I participated, included a fishery biological project with standard trawls, plankton nets and hydrography, furthermore

projects on benthos, microbiology, krill and primary production. Hence the cruise enabled a good presentation of the marine ecosystem in the region around Elephant Island and the Antarctic Peninsula, from 50 to 500 m depth.

Quantitative aspects: Our observations confirm previous observations of the antarctic environment. The antarctic winter was similar to the arctic winter: cold, dark, freezing to c. minus 25 degrees C. Sea ice was forming and also drifting out from the Weddell Seas just as it occurs in NW Greenland where the drift ice comes from the Canadian polar current.

The sea birds and the marine mammals, with a few exeptions, belonged to systematic groups different from the northern ones, but otherwise they showed many similarities in "lebensform" to the northern groups with some minor differences such as the penguins being more adapted to marine life, and the fur seals less adapted than their northern counterparts.

The plankton was also rather similar with the same major groups as in the north: salps, euphausiaceans, copepods, chaetognaths etc. Of cource there were different species in different proportions, but generally speaking not very different from the northern ones.

However the greatest shock was caused by the benthos and the fishes, and it was not only due to the animals found, but also what was lacking.

The benthos: As already recorded by many people the benthos is dominated by large sponges, echinoderms, bryozoans, isopods etc. After the first days of collecting and sorting,

I began to miss lifeforms and taxonomic groups, which are abundant in NW Greenland, for instance the balanomorph cirripeds, pectinaria-like polychaetes, decapods, bivalves and prosobranchs. These missing or rare invertebrates in the south are important food resources in the northern fishing grounds. It was a puzzle, that could not be explained by adaptation to the polar environment. Further the whole benthos appeared to be much older than the c. 20 MY, which was supposed to be the age of the Antarctic Circumpolar Current. It also seemed to be a unique and isolated fauna.

The fish fauna is dominated by the endemic Nototheniiformes with more than 50 species. However my impression is that the fish fauna is stereotyped. It did not show the variation in size, form, color etc., as seen in Greenland, where the fishes range from halibut wolffish and lumpsucker to chapelin and sandeel.

Quantitative aspects: During a minisymposium organized on board "Polarstern" some preliminary estimates of production and biomass were made. Hopefully the symposium will be continued in the spring 1987 with the final results. However a few results have already been published such as about the Primary production = 1200 kcal $m^{-2}y^{-1}$, krillproduction = 8 kcal $m^{-2}y^{-1}$, fish production = 2 kcal $m^{-2}y^{-1}$ (see Nast & Gieskes 1986, Siegel 1986, Kock 1986). The results support the hypothesis, that the pelagic sound scattering layer (= "false bottom") substitutes the benthos over deeper water (Petersen 1985).

The Antarctic generally seems to have a non-pelagic and non-seasonal reproduction. It benefits from the sinking pelagic production, but it also seems as if the organic

matter to a large extent is recycled within the benthos. It does not yield much to fish, birds or sea mammals.

The benthos from the tidal zone and down to 50 m depth was not sampled, but according to the literature (e.g. Dayton et al. 1970) anchor ice and scouring ice destroy life down to about 10 m or more. Tidal zone barnacles are missing even from the subantarctic islands, where ice has no real influence (Villiers 1976). This is also in contrast to the northern conditions, where a well developed tidal zonation can be found and where the coast is covered with an icefoot for severel months, and the sea is covered with one to two meter thick sea ice (Petersen 1962, 1977).

Comments and some consequences of Polar ecology

A survey of the literature showed that most of the recent studies have accepted the idea, that the Antarctic Circumpolar Current is about 20 MY old (e.g. Barker & Burrell 1982). Only a few indicated, that it could be of Jurassic origin: "The Antarctic ocean is an old system - established - during if not before Jurassic times" (Hedgpeth 1977 p. 4). Independently this also was my conclusion from the preliminary first observations.

The following working hypothesis for the evolution of the antarctic fauna was set up: When the Pangea broke up into smaller plates, it gave room for a watermass in which a more or less circumpolar current developed, and isolated part of the fauna. It was first a warm ocean, which was cooled down during the Tertiary. The cooling and the development of the polar night-polar day benefited the pelagic system which was first utilized by endemic and some oceanic fish, later by

endemic birds and latest by invading marine mammals. The benthos was not much affected by the climatic changes. It is supposed that the shelf areas have always been deep, also before glaciation.

So many observations support the model with a changing angle betwen ecliptica and the earth axis (e.g. Jefferson 1983, Petersen 1985, Williams & Douglas 1985) that it will not be discussed here. However in the discussions the belief can be met with, that evolution can result into almost anything if there is enough time. It is nessesary to introduce the concept: "determinable, predictable and limited evolution." Each environment has certain limits to diversity of species, sizes of populations, lifeforms, energetic positions, foodwebs etc. The environment can be taken as a matrix and the biosystem gives a cast, which is rather predictable. The matrix and the cast together are the ecosystem. The biosystem also reflects the ancient evolutionary potential of the ancient stock, which happened to be present when the new environment was formed. The environment and the energetic possibilities in the ecosystem determine the direction and the final result of evolution. The ancient stock and the biological processes like speciation, selection etc. are the means by which the biosystem adapts to the environmental mould. The study of evolution of environments and within ecosystems is concerned with lifeforms, analogies, functional morphology etc., while the study of evolution of taxa and evolutionary systematics is concerned with species, apomorphy, homologies etc. The present widely accepted theories on evolution do not seem to be adaequate for both kinds, where concepts like prallel development, adaptive zones etc. are mentioned in vague notes.

Literature

Barker, P.F. & J. Burrell, 1982: The influence upon Southern Ocean circulation, sedimentation, and climate of the opening of Drake Passage. - p. 377-386 in Craddock, C. (ed.): Antarctic Geoscience. - International Union of Geological Sciences. Ser. B.-no. 4. University of Wisconsin Press.

Dayton, Paul K., G.A. Robilliard & R.T. Paine, 1970: Benthic faunal zonation as a result of anchor ice at Mc Murdo Sound, Antarctic. - p. 244-258 in Holdgate, M.W. (ed.): Antarctic Ecology. Academic Press 604 pp.

Hedgpeth, Joel W., 1977: The Antarctic marine ecosystem, - p. 3-10 in Llano, George A. (ed.): Adaptations within Antarctic Ecosystems, Gulf Publishing Co., Houston. 1252 pp.

Jefferson, T.H., 1983: Paleoclimate significance of some Mesozoic antarctic fossil floras. - p. 593-598 in Oliver, R.L., P.R. James & J.B. Jago, (eds.): Antarctic earth science. - Australian Academy of Science, Canberra.

Nast, F. & W. Gieskes, 1986: Phytoplankton observations relative to krill abundance around Elephant Island in November 1983. - Archiv für Fischereiwissenschaft, 37 (1), 73-94.

Kock, K.H., 1986: The state of exploited antarctic fish stocks in the Scotia Arc region during SIBEX (1983-1985). - Ibid., 129-186.

Petersen, G. Höpner, 1962: - The distribution of Balanus balanoides (L.) and Littorina saxatilis, Olivi, var. groenlandica, Mencke in Northern West Greenland. - Meddelelser om Grönland, 159 (9), 42 pp.

Petersen, G. Höpner, 1977: - Biological effects of sea - ice and icebergs in Greenland. - p. 319-329 in Dunbar, M.J. (ed.): Polar Oceans. - Arctic Institute of North America, Calgary.

Petersen, G. Höpner, 1985: The eastern Mediterranean shelf ecosystem in global connexion including some biological and geological implications. - p. 147-162 in Moraitou-Apostolopoulou, M. & V. Kiorteses (eds.): Mediterranean Marine Ecosystems. - NATO Conference Series, serie 1: Ecology, vol. 8. Plenum Press.

Siegel, V., 1986: Structure and composition of the Antarctic krill stock in the Bransfield Strait (Antarctic Peninsula) during the second International BIOMASS experiment (SIBEX). - Archiv für Fischereiwissenschaft, 37 (1), 51-72.

Villiers, Anthonie F. de, 1976: Littoral ecology of Marion and Prince Edward Islands (Southern Ocean). - South African Journal of Antarctic Research, Supplement 1. 40 pp.

Williams, G.E. & J.G. Douglas, 1985: Comments on Cretaceous climatic equability in polar regions. - Palaeogeography, Palaeoclimatology, Palaeoecology 49, 355-357.